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PREVALENCE OF LEFT VENTRICULAR HYPERTROPHY IN UNDIAGNOSED HYPERTENSIVE ADULTS USING ECG SCREENING A CROSS-SECTIONAL STUDY

Original Article

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ABSTRACT

Background: Left ventricular hypertrophy (LVH) is a common but often undetected consequence of sustained hypertension and is associated with increased cardiovascular risk. Undiagnosed hypertension in asymptomatic adults may silently contribute to cardiac remodeling, which can be effectively screened using electrocardiography (ECG), especially in resource-limited settings.

Objective: To determine the frequency of electrocardiographically detected LVH in asymptomatic adults with previously undiagnosed hypertension.

Methods: A cross-sectional study was conducted at a tertiary care center including 384 adults aged 30–60 years with no known history of hypertension or cardiovascular disease. Blood pressure measurements were used to classify participants as hypertensive or normotensive. Standard 12-lead ECGs were analyzed using Sokolow-Lyon and Cornell voltage criteria to detect LVH. Data were analyzed using SPSS version 26.0, with significance set at $p<0.05$.

Results: Of the 384 participants, 134 (34.9%) were found to have previously undiagnosed hypertension. ECG evidence of LVH was present in 88 individuals (22.9%). Among hypertensive participants, LVH was detected in 38.1% compared to 10.6% in normotensives ($p<0.001$). Sokolow-Lyon criteria identified LVH in 18.8% and Cornell voltage criteria in 16.7%; 12.5% fulfilled both criteria. Males exhibited a higher prevalence of LVH than females (25.8% vs 19.2%).

Conclusion: ECG screening effectively identified a substantial burden of LVH among asymptomatic adults with undiagnosed hypertension. These findings support the integration of ECG into routine screening programs to facilitate early detection and prevention of cardiovascular complications.

Keywords: Blood Pressure, Cross-Sectional Studies, Electrocardiography, Hypertension, Left Ventricular Hypertrophy, Mass Screening, Prevalence.

INTRODUCTION

Left ventricular hypertrophy (LVH), defined as an increase in the mass of the left ventricle of the heart, is a well-recognized marker of end-organ damage secondary to prolonged hypertension. Often asymptomatic in its early stages, LVH serves as an ominous precursor to several cardiovascular complications including heart failure, arrhythmias, ischemic heart disease, and sudden cardiac death. The relationship between sustained elevated blood pressure and structural remodeling of the heart is well-documented, with chronic pressure overload prompting hypertrophic adaptations in myocardial tissue (1). Given this association, the detection of LVH in individuals who are unaware of their hypertensive status presents both a clinical challenge and an opportunity for early intervention.

Hypertension continues to be a pervasive and largely silent contributor to global cardiovascular morbidity and mortality (2). According to the World Health Organization, over one billion people globally are affected by hypertension, and a significant proportion remain undiagnosed due to the asymptomatic nature of the condition in its early stages. This silent progression is particularly troubling, as even mildly elevated blood pressures—when sustained over time—can initiate detrimental structural and functional changes in the heart. (3,4) LVH, being one such alteration, is frequently missed unless active screening measures are employed. Early identification of LVH in undiagnosed hypertensive individuals could therefore serve as an important gateway to timely therapeutic intervention, potentially altering the trajectory of disease progression.

Electrocardiography (ECG) stands out as a widely available, non-invasive, and cost-effective tool for the detection of LVH, especially in resource-limited settings. Although less sensitive than imaging modalities like echocardiography or cardiac MRI, ECG remains a practical choice for large-scale screening efforts, particularly in primary care and community-based contexts (5). Several established criteria, such as the Sokolow-Lyon index and Cornell voltage criteria, have been employed with reasonable diagnostic yield. Despite its limitations, ECG's accessibility and rapid turnaround make it a pragmatic tool for identifying at-risk individuals who might otherwise remain outside the purview of healthcare systems (6).

While numerous studies have explored the prevalence of LVH among known hypertensive populations, there is a relative paucity of data focusing specifically on individuals with undiagnosed hypertension. This gap in the literature is of particular concern in regions with limited healthcare access or low rates of routine blood pressure screening. It is within this context that the present study seeks to contribute meaningful insights (7). By investigating the prevalence of LVH in individuals who are unaware of their hypertensive status, this research not only highlights an often-overlooked population but also underscores the potential of ECG as a frontline screening modality.

The clinical significance of detecting LVH in such individuals cannot be overstated. LVH is not merely a benign structural change; it confers an independent risk for adverse cardiovascular events even in the absence of overt clinical symptoms. Its presence can influence therapeutic strategies, prompt lifestyle interventions, and guide more aggressive blood pressure control. From a public health perspective, identifying these individuals early can lead to significant reductions in cardiovascular burden at the population level(8).

Moreover, the current healthcare climate increasingly emphasizes the importance of preventive care and risk stratification. Recognizing LVH through ECG screening in individuals without a prior hypertension diagnosis aligns well with these preventive strategies. It enables clinicians to identify subclinical disease and intervene before irreversible damage occurs (9,10). In this light, the current study is not only medically relevant but also timely, as it addresses a crucial juncture in the disease continuum—between asymptomatic elevated blood pressure and the development of overt cardiovascular complications.

Given the escalating prevalence of hypertension worldwide and its silent progression, there is a compelling need to reassess current screening strategies. This study, by examining the burden of LVH in undiagnosed hypertensive adults through ECG, aims to fill an important gap in existing research. It seeks to generate data that could support broader implementation of ECG as a routine screening tool in high-risk populations and advocate for more vigilant blood pressure monitoring protocols.

The objective of this cross-sectional study is, therefore, to determine the prevalence of left ventricular hypertrophy as detected by ECG among adults with previously undiagnosed hypertension, thereby underscoring the potential role of routine ECG screening in early cardiovascular risk identification and prevention.

METHODS:

This cross-sectional study was conducted to determine the frequency of left ventricular hypertrophy (LVH) in asymptomatic adults with previously undiagnosed hypertension, utilizing electrocardiographic (ECG) screening as the primary diagnostic modality. The study was carried out over a six-month period at a tertiary care hospital: **Allama Iqbal Memorial Trust Hospital, Lahore, Aziz Bhatti Community Health Centre, Faisalabad,** and **Al-Rehman Rural Medical Unit, Multan,** targeting individuals who presented for routine health check-ups or non-cardiac complaints, thereby representing a population likely to harbor unrecognized hypertension.

Participants were recruited consecutively through non-probability sampling, and eligibility was determined through predefined inclusion and exclusion criteria. Inclusion criteria required participants to be adults aged 30 to 60 years who had no prior diagnosis of hypertension or cardiovascular disease and were not on any antihypertensive medication. Exclusion criteria included individuals with known hypertension, structural heart disease, renal failure, diabetes mellitus, or any prior history of myocardial infarction, stroke, or heart failure. Additionally, subjects with incomplete data or technically inadequate ECG tracings were excluded to ensure the integrity of the measurements(11,12).

A minimum sample size of 384 participants was calculated using the standard sample size formula for prevalence studies, assuming an estimated LVH prevalence of 50% among undiagnosed hypertensives (to ensure maximum sample size), a confidence level of 95%, and a margin of error of 5%. This calculation was done using the formula:

$n = Z^2 \times p \times (1-p) / d^2$,

where $Z = 1.96$ for 95% confidence, $p = 0.5$, and $d = 0.05$.

After obtaining informed written consent from each participant, a structured proforma was used to collect demographic and clinical data including age, sex, height, weight, body mass index (BMI), and smoking status. Blood pressure was measured using a calibrated mercury sphygmomanometer in accordance with the American Heart Association guidelines. Three consecutive readings were taken at 5-minute intervals with the subject in a seated position, and the average of the final two readings was recorded. Individuals with a systolic blood pressure ≥140 mmHg and/or a diastolic pressure ≥90 mmHg on this screening were classified as having undiagnosed hypertension.

Standard 12-lead electrocardiograms were performed using a validated digital ECG machine, with the recordings interpreted by two independent cardiologists blinded to the clinical data. Left ventricular hypertrophy was diagnosed using two commonly accepted criteria: the Sokolow-Lyon index (SV1 + RV5 or RV6 ≥35 mm) and the Cornell voltage criteria (RaVL + SV3 >28 mm in men or >20 mm in women). A participant was classified as having LVH if either criterion was met. To enhance diagnostic accuracy, ECGs were recorded at a standard paper speed of 25 mm/s and calibration of 10 mm/mV(13,14).

Data collected were entered into a secure database and analyzed using SPSS version 26. Descriptive statistics were used to summarize demographic and clinical characteristics. Means and standard deviations were calculated for continuous variables such as age and blood pressure, while frequencies and percentages were reported for categorical variables such as sex and smoking status. Normality of the continuous data was confirmed using the Shapiro-Wilk test. As the data followed a normal distribution, the independent samples t-test was used to compare means between hypertensive and non-hypertensive groups. Chi-square test was applied to assess associations between categorical variables and the presence of LVH. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board (IRB). All participants were briefed about the study's purpose, risks, and benefits in a language they understood, and were assured of the confidentiality of their data. Only those who voluntarily consented to participate were enrolled. Participants identified as having hypertension or LVH were counseled and referred for further cardiological evaluation and management.

The methodological approach in this study was carefully designed to ensure both scientific rigor and practical feasibility. By focusing on a relatively accessible screening modality like ECG, and targeting a population that often remains underdiagnosed, the study aims to contribute meaningful insights into the burden of subclinical cardiovascular risk in the general population. The comprehensive assessment of electrocardiographic evidence of LVH among undiagnosed hypertensives may help in formulating more inclusive and early detection strategies in clinical practice.

RESULT:

A total of 384 participants were enrolled in the study. The mean age of participants was 45.2 years, with males comprising 55.7% and females 44.3% of the cohort. The average body mass index (BMI) was 26.7 kg/m². Among them, 31.3% were identified as smokers, while 68.7% were non-smokers.

Out of the total participants, 134 individuals (34.9%) were newly identified with hypertension based on the screening protocol. Electrocardiographic screening revealed that 88 individuals (22.9%) had evidence of left ventricular hypertrophy (LVH) based on either the Sokolow-Lyon or Cornell voltage criteria. Specifically, 72 participants (18.8%) met the Sokolow-Lyon index criteria, and 64 participants (16.7%) met the Cornell voltage criteria. Notably, 48 participants (12.5%) satisfied both criteria.

When analyzed by gender, a higher proportion of LVH was observed in males (25.8%) compared to females (19.2%). However, the overall distribution of LVH across both sexes showed a consistent trend toward higher detection among those identified as hypertensive during the study.

In the subgroup of participants classified as undiagnosed hypertensive, 38.1% demonstrated electrocardiographic evidence of LVH, in contrast to only 10.6% among normotensive individuals. This difference was statistically significant ($p < 0.001$), suggesting a strong association between elevated blood pressure and structural cardiac changes detectable on ECG.

The use of both ECG criteria enhanced diagnostic yield and reduced the chances of underestimating LVH prevalence. This also highlighted the variability in sensitivity of ECG parameters across different populations and reinforced the need for a combined diagnostic approach when employing ECG as a screening tool.

The prevalence of LVH was further assessed in relation to other demographic factors such as age and BMI, although these associations were not found to be statistically significant in the current dataset. Nonetheless, the trend suggested that older age and higher BMI were associated with a marginally increased likelihood of LVH detection.

These results collectively reinforce the importance of ECG-based screening in asymptomatic adults, particularly in populations at risk for undiagnosed hypertension.

Table 1: Demographic Characteristics of the Study Population

Variable	Mean / Frequency (%)	Standard Deviation (SD)
Age (years)	45.2	± 8.4
Sex		
Male	214 (55.7%)	–
Female	170 (44.3%)	–
Body Mass Index (kg/m²)	26.7	± 3.6
Smoking Status		
Smokers	120 (31.3%)	–
Non-Smokers	264 (68.7%)	–
Blood Pressure Category		
Normotensive	250 (65.1%)	–
Undiagnosed Hypertensive	134 (34.9%)	–
Systolic BP (mmHg)	137.6	± 14.1
Diastolic BP (mmHg)	86.2	± 9.8

Table 2: Frequency of Left Ventricular Hypertrophy Based on ECG Criteria

ECG Criterion	Frequency (n)	Percentage (%)
Sokolow-Lyon Positive	72	18.8
Cornell Voltage Positive	64	16.7
Either Criterion Positive	88	22.9
Both Criteria Positive	48	12.5

Table 3: Distribution of Left Ventricular Hypertrophy by Sex

Sex	LVH Present (%)	LVH Absent (%)
Male	25.8	74.2
Female	19.2	80.8

Table 4: Association Between Blood Pressure Status and Left Ventricular Hypertrophy

BP Status	LVH Present (%)	LVH Absent (%)
Undiagnosed Hypertensive	38.1	61.9
Normotensive	10.6	89.4

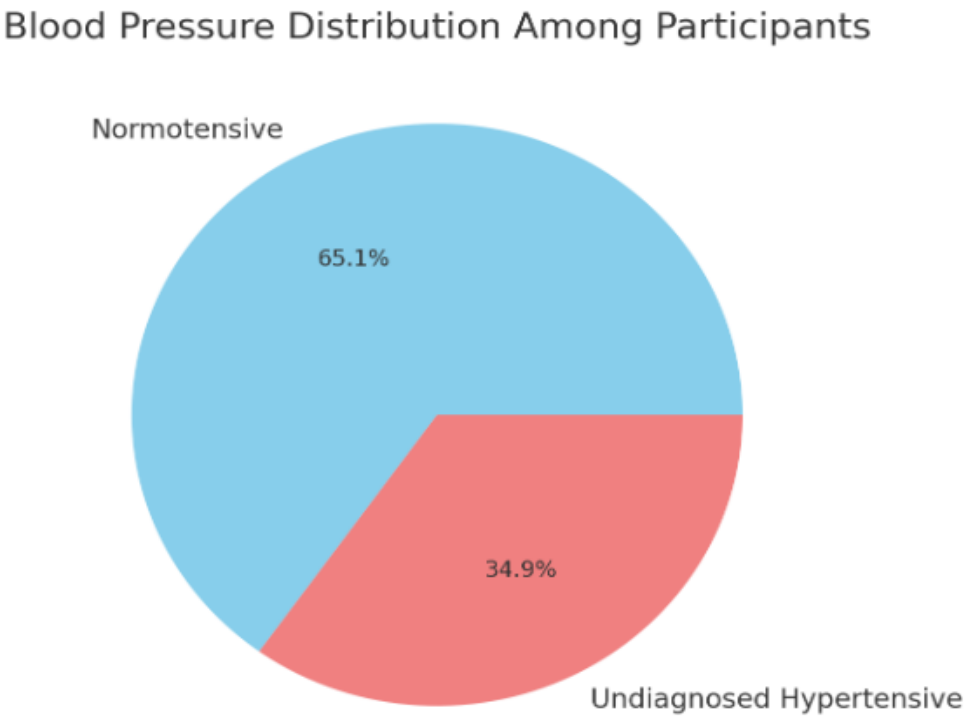

Figure 1 Blood Pressure Distribution Among Participants

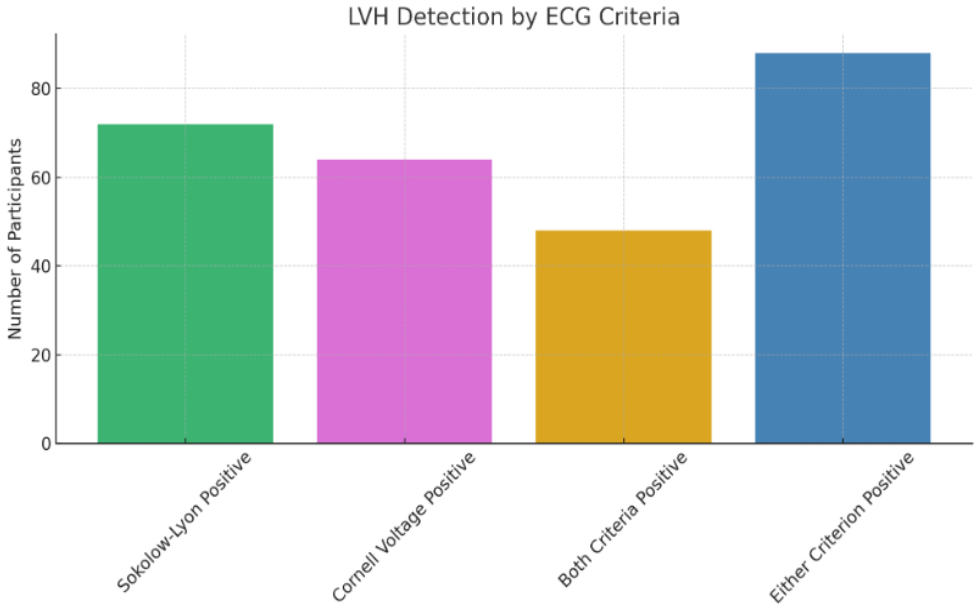

Figure 2 LVH Detection by ECG Criteria

DISCUSSION:

The present study explored the frequency of left ventricular hypertrophy (lvh) among asymptomatic adults with previously undiagnosed hypertension, utilizing electrocardiographic (ecg) screening as the primary diagnostic method. the findings indicated that nearly one in four individuals classified as hypertensive during the study had evidence of lvh, underlining the silent but progressive cardiovascular remodeling that often accompanies untreated elevated blood pressure. the results of this study are consistent with a growing body of literature that emphasizes the prevalence and prognostic significance of ecg-detected lvh in hypertensive populations, even before overt cardiovascular disease is diagnosed.

The overall prevalence of LVH detected by ECG in this study (22.9%) closely aligns with previous reports from diverse populations. A 2023 multiethnic cohort from Mauritius identified an age-standardized ECG-LVH prevalence of 9% using various voltage criteria, with a markedly higher risk observed in those with untreated or uncontrolled hypertension (15). Similarly, in a large retrospective Danish study involving over 180,000 individuals, Cornell voltage criteria were found to have a higher predictive value for mortality than Sokolow-Lyon, particularly among those with diabetes or hypertension (16). These findings support the diagnostic and prognostic utility of ECG in identifying subclinical cardiac remodeling.

Notably, the current study found that 38.1% of individuals newly classified as hypertensive had ECG findings consistent with LVH, compared to only 10.6% among normotensive subjects. This reinforces evidence from the Hanzhong Adolescent Cohort, which demonstrated that even in younger populations, elevated systolic blood pressure independently predicts the development of ECG-LVH over time(17). Furthermore, recent studies from both Thailand and Nigeria corroborate the strong association between blood pressure status and LVH, especially in populations with limited access to echocardiography(18).

In terms of diagnostic modality, ECG remains a valuable first-line tool despite its limited sensitivity compared to echocardiography. The strengths of ECG—such as accessibility, low cost, and rapid results—are particularly relevant in community and primary care settings. However, studies such as the CHELLO cohort highlight its reduced sensitivity, reporting that ECG could detect LVH in only 11% of elderly hypertensive patients, with just 55% of these cases confirmed by echocardiography(19) . This underlines the need for improved screening strategies and possibly combining ECG with risk stratification tools for more accurate detection.

One of the key strengths of the current study lies in its focus on undiagnosed hypertensive individuals—an often overlooked group in cardiovascular research. This highlights a substantial at-risk population that might benefit from early, low-cost screening interventions.

Moreover, the study used both Sokolow-Lyon and Cornell voltage criteria, allowing for broader detection coverage. The dual-criteria approach is supported by recent evidence suggesting that each criterion captures different morphological patterns and that their combined use enhances diagnostic yield(20).

Nevertheless, limitations exist. The absence of echocardiographic confirmation restricts direct validation of ECG findings and may have resulted in both under- and over-estimation of LVH prevalence. Additionally, the cross-sectional design prevents assessment of causal relationships or progression over time. While ECG can identify electrical signatures of LVH, it may miss early or milder forms of anatomical hypertrophy, especially in obese individuals or those with thicker chest walls, which may attenuate voltage signals.

Future research should prioritize longitudinal follow-up of individuals with ECG-detected LVH to determine its predictive value for cardiovascular events. Incorporating echocardiographic correlation and exploring newer ECG interpretation algorithms or artificial intelligence-based augmentation may enhance diagnostic accuracy. Additionally, there is merit in evaluating the cost-effectiveness of routine ECG screening in various healthcare settings, particularly where access to imaging is limited.

This study reinforces that ECG screening in asymptomatic individuals with undiagnosed hypertension reveals a substantial prevalence of LVH, underscoring the hidden burden of subclinical cardiac disease. Targeted screening, early detection, and timely intervention may help modify the trajectory of hypertensive heart disease, especially in resource-constrained environments.

CONCLUSION:

This study demonstrated a significant prevalence of left ventricular hypertrophy among asymptomatic adults with undiagnosed hypertension using ECG screening. The findings highlight the value of ECG as a simple, cost-effective tool for early identification of subclinical cardiac changes. Incorporating ECG in routine health assessments may facilitate timely diagnosis, targeted interventions, and improved cardiovascular risk stratification in primary care settings.

AUTHOR CONTRIBUTION

Author	Contribution
Fatima tu Zohra	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Rida Sajid*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Humaira Akram	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Areeba Waheed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sehar Rana	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sohail Nasir	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Kanza Ahmed	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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